Concepts For Ocean Worlds Life Detection Technology

Europan Molecular Indicators of Life Investigation (EMILI)

Completed Technology Project (2015 - 2018)

Project Introduction

The Europa Lander mission represents an enormous opportunity to capitalize on scientific discoveries at Europa by enhancing its planned exploration, toward a direct search for signs of life. The full understanding of Europa's habitability will be established by the Europa Multiple Flyby Mission (EMFM). The EMFM payload, including highly capable imagers, spectrophotometers, mass spectrometers, and particle and wave sensors, will make critical observations of Europa's subsurface ocean, its complex icy surface, and its surface-bounded exosphere to produce a clear picture of the extent and cycling of its water and chemical inventories. With this foundation, a follow-up lander will then be able to address hypotheses about key astrobiological markers in the icy surface. If deep plume activity is confirmed, the lander could potentially sample fresh, ocean-borne surface deposits for biosignature detection. With these ambitious objectives, relative to the timeframe for lander payload selection, it is absolutely imperative to focus attention on instrument technologies that both (1) address expected complex molecular detection and characterization requirements with exquisite sensitivity and specificity, and (2) are on a realistic technical path to compatibility with the extreme payload resource and environmental constraints of a Europa surface mission. We propose to mature a Europa-specific implementation of the Linear Ion Trap Mass Spectrometer (LITMS) investigation to meet these dual requirements in the search for signs of extant life. LITMS is a dual-ion source precision molecular analyzer derived from the substantial heritage of the Mars Organic Molecule Analyzer (MOMA) investigation under development in our lab for the ExoMars rover. LITMS brings the power of both gas chromatography mass spectrometry (GCMS) and laser desorption mass spectrometry (LDMS) of solid samples to fine spatial scales (sub-mm) with its precision analyses. As on Mars, detection of complex organics at fine scales offers significant advantages in examining features key to distinguishing biogenic and abiogenic molecules, compared to bulk analysis. LITMS further provides enhanced capabilities, compared to MOMA, including detection of both positive and negative ions, a wider range of molecular weights (to over 2 kDa), and direct evolved gas analysis – all of which substantially increase the sensitivity of LITMS to the widest possible range of molecular organic biosignatures within their geochemical context. LITMS has been developed for the past three years with support of the MatISSE program, and will achieve TRL 6 for Mars surface operations at the end of this year. To re-achieve TRL 6 for a Europa lander mission focused on extant life, we will focus our COLDTech effort in three critical areas: (1) Refinement and validation of the precision sampling GCMS + LDMS operational modes for characterization of trace complex molecular biosignatures in cryogenic Europan samples; (2) Analysis, testing, and optimization of the appropriate LITMS hardware and operational mitigation approaches for the intense penetrating radiation at Europa; and (3) Design and development of a flight-like LITMS brassboard for Europa that (3a) rigorously meets PDR-level TRL 6 criteria, and (3b) enables a flight design demonstrably compliant with the most stringent planetary protection and

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Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Responsible Program:

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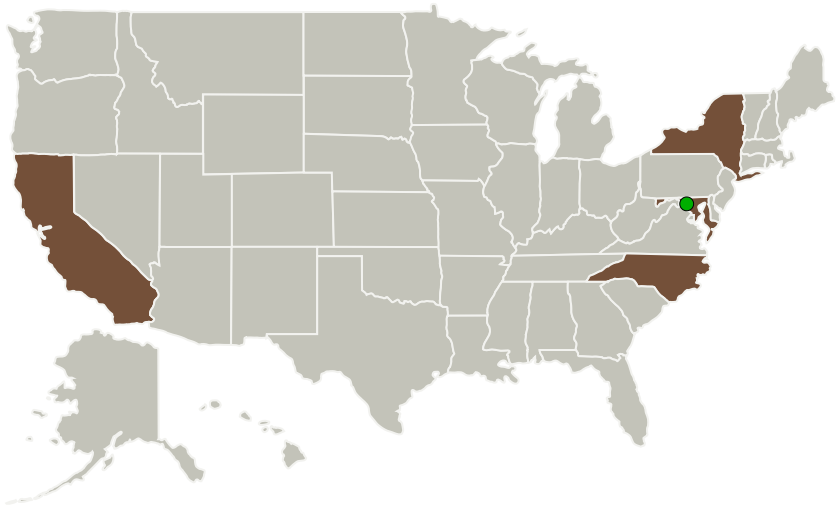
contamination control requirements of the mission. Lacking a requirement to redesign the core LITMS analyzer, which has already been developed at flight scale and meets extremely challenging measurement requirements for Mars missions, our proposed COLDTech development is able to devote significant and necessary attention to the Europa-specific features to minimize technical and cost risk of an eventual flight model. With COLDTech support we anticipate that LITMS could be among the few investigations that would be fully ready for the challenge of contributing to direct detection of life on Europa.

Anticipated Benefits

The results of this project may be used to enable advanced, highly-sensitive measurements of potential molecular biosignatures on Ocean Worlds astrobiology missions such as the Europa Lander, currently under study. Specifically this project would allow adaptation of current state-of-the art methods for molecular analysis via mass spectrometry, developed for Mars surface missions, to be applied to the potential detection of extant life in challenging outer solar system environments.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Goddard Space Flight Center(GSFC)	Supporting Organization	NASA Center	Greenbelt, Maryland

Project Management

Program Director:

Carolyn R Mercer

Program Manager:

Carolyn R Mercer

Principal Investigator:

William B Brinckerhoff

Co-Investigators:

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Erin N Lalime
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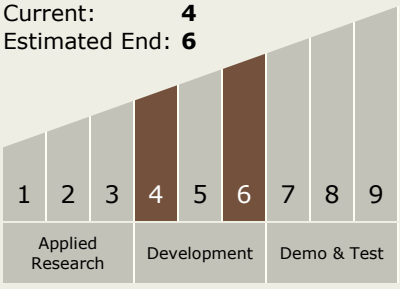
Philip Chu

Technology Maturity (TRL)

Start: **4**
Current: **4**
Estimated End: **6**



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Primary U.S. Work Locations	
California	Maryland
New York	North Carolina

Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.3 In-Situ Instruments and Sensors
    - TX08.3.4 Environment Sensors

Target Destination

Others Inside the Solar System